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Using a Borated Panel to Form a Dual Neutron-Gamma Detector

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INTRODUCTION

A borated polyethylene plane placed between a neutron source and a gamma spectrometer is used to form a dual neutron-gamma detection system. The polyethylene thermalizes the source neutrons so that they are captured by ^{10}B to produce a flux of 478 keV gamma-rays that radiate from the plane. This results in a buildup of count rate in the detector over that from a disk of the same diameter as the detector crystal (same thickness as the panel). Radiation portal systems are a potential application of this technique.

DESCRIPTION OF WORK

This work builds on the work of Ghanbari and Mohagheghi (2001) where borated polyethylene caps were placed over a NaI detector to form a dual neutron-gamma system. In our work measurements were performed using a 5% borated polyethylene plane, a ^{252}Cf source, and a HPGe system. The borated plane had dimensions of 1.22 m × 1.22 m × 2.54 cm. The detector crystal had a diameter of 77.7 mm and 102.1 mm in length and a relative efficiency of 103.2% at 1,332 keV. The source had a yield of 1.11×10^6 neutrons/second on the assay date of March 16, 2001. These components were set up as shown in Figure 1.

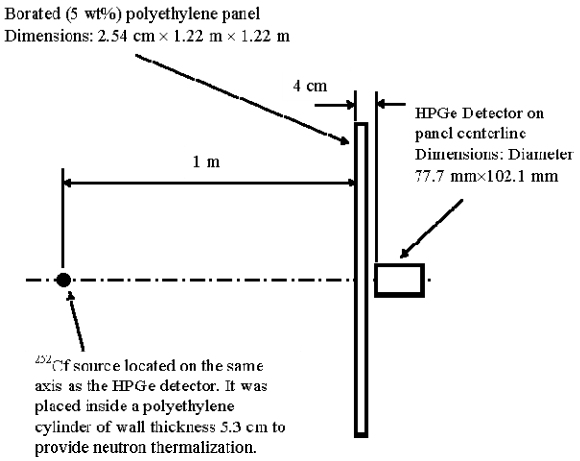

Figure 1: The experimental layout to measure the count rate buildup factor.

RESULTS

Data was collected in February 2007 for a live time of 1,800s. The net counts under the 478 keV peak were 11,286±324. This plane was replaced by a disk cut from a corner of the plane of 9.6 cm diameter. The experimental run was performed again for the same live time yielding 2,462±268. The buildup factor was calculated as the ratio of the plane to disk counts and was found to be 4.6±0.5. A second run was performed in June 2007 for a live time of 7,048s for the plane and 7,200s for the disk with everything else the same as before. The buildup factor was determined as before to be 4.3±0.4. The average buildup factor is therefore 4.4±0.3.

A comparison calculation was made between this technique and ^3He tubes (Model: RS-P4-0406-212) manufactured by Reuter Stokes. According to the GE Reuter Stokes Web Page Fact Sheet (2007), these tubes have a sensitive volume that measures 1.27 cm in diameter by 15.24 cm in length, and the quoted sensitivity is 8 cps cm^2 s. The tube was assumed to be placed perpendicular to the neutron arrival direction, and the neutron flux was assumed to be unperturbed when arriving at the tube from a fully thermalized point neutron source placed 1 m away. This maximizes the count rate at the tube. The cross section of the tube (19.4 cm^2) displayed to the source was corrected to match the front surface area of the detector (47.4 cm^2) and the count rate was adjusted accordingly. The ratio of the maximized ^3He tube count to that of this technique is 3.8.

This method converts a spectrometer into a dual neutron-gamma detector system while maintaining spectrometer capability. In this investigation, the plane was placed in front of the detector; however, it could be placed behind it to minimize attenuation concerns. Most of the 478 keV gamma-rays that arrive at the detector originate from the region of the borated plane that is not directly in front of the detector (most likely angle of arrival is about 45^0 to the detector face). The "sweet spot" of the arrangement is located with the detector in contact with the center of the plane at the point closest to the neutron source. The ^3He tube comparison performed in the manner described here indicates greater efficiency. However, recall that the comparison assumes a fully thermalized neutron source for the ^3He tube calculation, and that the experimental setup described here is not optimized to maximize count

rate. The true difference in sensitivity is likely to be less than the factor of 3.8 described in this work.

REFERENCES

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